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EFFECT OF POTASH ON GRADE, SHAPE, AND YIELD OF CERTAIN VARIETIES OF SWEETPOTATOES GROWN IN SOUTH CAROLINA

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INTRODUCTION

It is important to the sweetpotato grower that he obtain the highest possible proportion of his total harvested crop as well-shaped roots of U. S. No. 1 grade.[1] Jumbos and No. 2's have little market value at any time, and in years of ample supply they may be entirely unmarketable. Roots that are quite divergent in character from those commonly regarded as typical of the variety represented may also have a relatively low market value, even though they are sound and of fair size. Thus, as grown for the market, the value of a grower's crop is calculated almost entirely on the yield of the No. 1 grade.[2]

It is commonly known that root shapes and sizes of sweetpotatoes vary within wide limits, even for a single variety, and some varieties appear to be more variable than others under the same conditions. Physical properties of the soil, time of planting, cultural practices, drainage, and nutrient supply have all been mentioned by numerous investigators and observers as markedly affecting size, shape, and grade of roots as well as yield.

The sweetpotato is known to be particularly adapted to sandy loam and sandy soils that are adequately supplied with available plant nutrients. Most references to the sandier soils are in essential agreement as to the moderate to low native fertility of such soils. It has become a more or less general belief that sandy loam and sandy soils are notoriously low in potash, always requiring rather heavy applications of potash year after year for any vegetable crop grown on them. From the striking responses of sweetpotatoes to potash in New Jersey, Maryland, and Florida there has been some tendency to infer that all the lighter soils of the Atlantic coast and Gulf coast regions would show similar responses to potash on this crop.

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[1] Whenever grades are mentioned in this circular they refer to the size requirements of the U. S. Jumbo, U. S. No. 1, and U. S. No. 2 grades issued by the Bureau of Agricultural Economics, U. S. Department of Agriculture, Sept. 8, 1925.

[2] If a large sweetpotato-starch industry develops, the total yield will be of new interest.

The studies reported in this circular were planned to determine (1) how different varieties would respond to increasing amounts of potash with reference to grade, shape, and yield, and (2) to what extent the remarkable findings in New Jersey might apply in the Coastal Plain section of South Carolina.

REVIEW OF LITERATURE

No effort will be made here to review all the numerous sweetpotato fertilizer experiments reported in this country. Only a few of the more recent studies will be mentioned because of their interest in relation to this potash question in the Atlantic and Gulf States.

Scott (*8*)[3], in Florida, reported for Triumph sweetpotatoes a 5-year average total yield of but 65 bushels per acre on plots receiving 112 pounds of dried blood plus 224 pounds of superphosphate, whereas plots treated with an additional 84 pounds of muriate and sulphate of potash, respectively, yielded 204 and 186 bushels.

Geise (*3*), in Maryland, conducted 3-year fertilizer studies with the Big Stem Jersey variety. The relative total yields for check, nitrogen, phosphoric acid, and potash treatments alone were 100, 135, 137, and 260 percent, respectively. When 200 pounds per acre of muriate of potash were added to the nitrogen, to the phosphoric acid, or to the nitrogen plus phosphoric acid treatments, the resultant yields were approximately 290, 291, and 300 percent of the check.

Schermerhorn (*7*), in New Jersey, reported fertilizer studies on Yellow Jersey involving a 21-mixture triangle or so-called balanced ratio comparison with 2-percent differences in each constituent. He showed markedly increasing yields of No. 1 and total yields as the percentage of potash in the mixtures was increased, despite corresponding decreases in amounts of nitrogen or phosphoric acid. In another series the 2-year mean yield of No. 1's from no potash (1,200 pounds of 2–8–0) was 53 bushels and from 2–8–10 was 101 bushels. On another farm, 1,400 pounds per acre of 3–8–0 and 3–8–8, respectively, gave 24 and 153 bushels of No. 1's. High potash and low nitrogen resulted in attractive, thick, chunky roots of medium length, and the reverse mixture resulted in long, slender roots of low market value. Schermerhorn observed a similar effect of high versus low potash when the nitrogen and phosphoric acid was held constant in the several mixtures. He concluded that a 3–8–8 mixture was most satisfactory.

Zimmerley (*12*) conducted a study on the Eastern Shore of Virginia with a 21-mixture triangle system of treatments, each constituent in the mixtures varying in 3-percent steps. One thousand pounds per acre were applied before planting. The 9-year mean yields of prime roots of Big Stem Jersey showed an almost perfect rank-order correlation with percentage of potash in the mixtures regardless of percentage of nitrogen and phosphoric acid, increasing from 197 bushels per acre for the 3–15–3 plots to 289 bushels for the 3–3–15 plots.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 23.

Carolus (*2*) in 1932 determined shape indexes of roots harvested from plots on the Eastern Shore of Virginia receiving treatments as described in the preceding paragraph. In only one comparison, 12–3–6 versus 12–6–3, did the higher potash treatment show a significantly chunkier type of root than the lower potash treatment. All comparisons of differences due to single elements were complicated, however, by the accompanying differences in a second element in the treatment. No consistent effect of potash on shape was observed.

The results in four of these five studies emphasize the importance of potash and the relatively small increases in yield from nitrogen or phosphoric acid. It was largely with these results in mind that the present investigation was undertaken to determine their applicability to other varieties and to another area. Since the present study was started, reports have appeared from Georgia, North Carolina, and Louisiana, some of which show much less marked responses to potash.

Skinner, Williams, and Mann (*9*), working at a number of locations in North Carolina with several varieties and soil types with a 21-mixture triangle system of treatments, obtained different results under the various conditions. In most cases yields increased moderately or slightly with increasing potash up to 6 or 9 percent, then decreased for 12 and 15 percent. In several cases the 0–0–15 treatment yielded less than the no-potash mixtures, probably because of the absence of nitrogen and phosphoric acid from the treatments.

Woodard (*11*), in Georgia, studied the effect of increasing potash in 2-percent steps when nitrogen and phosphoric acid were held constant at 4 and 8 percent in 800 pounds of the mixtures applied on Tifton sandy loam. Accompanying increasing potash, Jumbo yields increased from but 1 to 10 bushels per acre. Yields of No. 1's increased from 70 for no potash up to 150 bushels per acre for 6-percent potash but were not significantly greater for the 8- and 10-percent potash. Yields of No. 2's and strings remained practically constant.

Miller and Kimbrough (*5*), in Louisiana, set up a study on Lintonia silt loam, exactly the same as Woodard's. On land that had not been fertilized for some years, 4–8–0 yielded 290 bushels of No. 1's per acre, and yields increased gradually up to 321 bushels for 4–8–10. The yields for Jumbos increased from 7.5 to 11.5 bushels per acre, while those of No. 2's and culls remained constant. On fields that had been intensively cropped and fertilized for several years, there were no significant increases due to potash.

Work of Anderson and Richardson (*1*), in southern Mississippi with Triumph and of Hotchkiss (*4*) with the Dooley variety in eastern Texas showed no response to as much as 100 to 150 pounds of sulphate of potash. Current work of Anderson in southern Mississippi with Triumph (unpublished) shows very small and insignificant increases in yield with 800 pounds of mixtures containing more than 4 percent of potash (with 4 percent of nitrogen and 8 of phosphoric acid) on Cahaba and new Ruston soils; 4–8–12 fertilizer yielded 10 to 20 percent more (statistically insignificant) than the 4–8–4 on old Ruston and Orangeburg soil.

From this brief review it is evident that generalization should not be made as to the fertilizer requirements of sweetpotatoes. It seems to the authors that there has been a tendency to overrate the need of applying large quantities of potash to sweetpotatoes in many localities. There would seem to be few areas in which it is definitely known to be profitable to apply the equivalent of more than 100 pounds per acre of muriate or sulphate of potash (approximately 50 pounds of K_2O) together with sources of nitrogen and phosphoric acid.

METHODS AND MATERIALS

SOILS

The plots in 1929, 1930, and 1933 to 1935 were located on soil classified as Orangeburg sandy loam; in 1931 and 1932 on Norfolk sandy loam. The land used in 1929 to 1931 had been devoted to the growing of a variety of crops under moderately intensive methods of culture for many years and appeared to be of better than average fertility for the soil type in that locality. The plots in 1932 to 1935 were located on land generally known to be distinctly less productive than that used the previous 3 years to determine if more marked responses to potash would result.

VARIETIES

During the first 3 years of the study only the Porto Rico variety was grown, since it is the principal variety grown in the region where these studies were made. Disparity of preliminary results with those obtained elsewhere raised the question as to what extent this disparity might be due to differences between the varieties used. The latter 4 years of the work included Big Stem Jersey in order that direct comparison might be made with results obtained in Maryland and New Jersey by other investigators (*3*, *6*, *7*). Nancy Hall was also included, as it is the second most important variety in the South. All varieties were represented by good stocks that had been maintained by the Division of Fruit and Vegetable Crops and Diseases for many years.

FERTILIZER TREATMENTS

From 1929 to 1931 five fertilizer grades were applied, namely, 3–8–3,[4] 3–8–6, 3–8–9, 3–8–12, and 3–8–15. The nitrogen was derived equally from nitrate of soda, sulphate of ammonia, and cottonseed meal; the phosphoric acid from superphosphate; and the potash from muriate of potash. The requisite materials for each treatment were mixed by repeated turnings with shovels and the mixtures applied by hand in the ridge, at the time the ridges were made up, 2 to 4 weeks prior to transplanting. Fertilizer was applied at the rate of 500 pounds per acre.

The treatments and methods were the same as above during 1932 to 1935 except that a 3–8–0 fertilizer was included.

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[4] Percentages, respectively, of nitrogen, phosphoric acid and potash.

PLOT ARRANGEMENT AND SIZE

In 1929 to 1931 the treatments of the single variety, Porto Rico, were systematically replicated four times. In 1932 to 1935 three varieties were used and each variety was planted in a large block to itself, although the entire planting each year occupied a single continuous area. Within each variety block there were five subblocks or replications, within each of which the six treatments were systematically distributed. This arrangement, of course, makes impossible an accurate comparison of varieties within a single test (year) for there were no replications of variety. In the tables of analysis of variance (tables 4, 6, 10) the term "variety" really therefore involves the variation due to variety and block combined.

Despite the disadvantage mentioned, it is believed that in this case the arrangement of varieties was superior to distributing them over all the experimental area. Marked differences in vining habit would have introduced possible undesirable border competition in the small plots.

In 1929 to 1931 each plot consisted of four 90-foot rows; in 1932 to 1935, six or eight 15-foot rows. The smaller-sized plots permitted more detailed study of the entire crop per plot and resulted in lower variance due to or involving replication.

CROP PRODUCTION AND HARVESTING

Plants or draws for planting the experimental plots were grown in coldframes from seed stock treated to control disease, recommended sanitary precautions being observed. The plants were transplanted by hand onto ridges that had been dragged and firmed down to a height of 8 to 10 inches. Rows were 4 feet apart and the plants a foot apart in the rows. Planting dates varied from year to year but were between May 15 and May 31.

Shallow cultivation was given as often as necessary to control weeds.

The roots were harvested late in October or early in November by plowing out deeply and removing them from the soil by hand. They were graded into the United States grades of Jumbo, No. 1, and No. 2 as they were picked up, and each grade was weighed. No record was made of "strings" (roots too small to be of value). There is no commonly accepted minimum size of such roots that can be considered as a "sweetpotato," and below which they are merely "roots." It was believed that any attempt to collect detailed data upon this material would be of little or no practical value; and because of the indistinct demarkation between "sweetpotatoes" and mere "roots," data on numbers, sizes, and shapes might greatly and unfairly distort certain values for the total crop. The weight of such material left in the field was always very small in proportion to the harvested crop.

MEASURING ROOT SHAPES

In 1929 to 1931 the entire yield of Jumbos and a maximum of about 200 roots of each of the other two grades from each replicate of the 3-8-3 and 3-8-15 treatments were cured and stored in a sweetpotato storage house in the approved manner, so they could be measured for shape during the fall and winter. Unfortunately, the weights of the samples of No. 1 and No. 2 grades stored for subsequent measurement were not recorded before storage, hence no accurate mean shapes for the total of the three grades can be calculated, or for the 3 years' means for grades No. 1 or No. 2.

In 1932 to 1935 the plots were small enough so that the entire yield of each grade was cured, stored, and subsequently measured for shape. Mean values for these can, therefore, be calculated on a properly weighted basis.

During the 7 years' work some 30,000 roots were measured in length and maximum diameter to the nearest millimeter (one twenty-fifth of an inch). Length was measured between points on the axis of the root having a minimum diameter of 1 cm (two-fifths of an inch). Sweetpotato ends less than 1 cm in diameter are usually broken off in harvesting, and, furthermore, might well be considered only as root in the common sense of the word, rather than sweetpotato or tuberous root proper.

The shape was calculated for each root measured, by dividing its length by the diameter. Some have stated that the shape index should be calculated reciprocally, the diameter divided by the length, but there is no apparent reason for so doing in the present case. The method used here has a minor advantage in accuracy and ease of handling arithmetical calculations by the slide rule and computing machine that made it seem preferable.

STATISTICAL ANALYSIS

All data upon total yield and percentage of yield of each grade were analyzed by Fisher's analysis of variance as adapted by Snedecor (*10*). Magnitudes of minimum differences required for significance between any two values or means are calculated as twice the standard error of the difference. The standard error is calculated from the variance for remainder error (see tables 2, 4, 6, 8, 10). In calculating variance for the 7 years' data on the Porto Rico variety alone (tables 1, 2, 7, 8) the fifth replication and the 3–8–0 treatment were dropped for 1932 to 1935 and the table set up uniformly for four replications and five treatments only.

In the tables of analysis of variance the variances that are significant in comparison with remainder variance (error) are indicated by reference to footnotes. The footnotes refer to the magnitude of the respective *F* values. An *F* value that "exceeds the 1-percent point" indicates high odds of significance—greater than 99:1; a value that "exceeds the 5-percent point but not the 1-percent point" represents medium odds of significance—between 19:1 and 99:1.

Because of the widely varying numbers of items involved in the several classes of root shape indexes, those data were not subjected to analysis by the variance method. It would seem that the old conventional calculation of means and probable errors of indexes for classes and groups of classes should enable one to tabulate values permitting a greater number of interesting direct comparisons than is possible under the restrictions of the variance method.

RESULTS

YIELDS PER ACRE

Table 1 shows the mean yields of each grade and total yields of quadruplicate plots of the Porto Rico variety treated with a fertilizer mixture containing 3 to 15 percent potash from 1929 to 1935; the

7-year mean yields of each grade and total for each treatment; and the respective means for all treatments for each year. Table 2 presents the results of analysis of variance of the complete data entering into table 1.

TABLE 1.—*Effect of increasing potash in fertilizer on yield per acre of each United States grade and total yield of Porto Rico sweetpotatoes, Florence, S. C., 1929–35*

[Plots replicated 4 times]

Grades and fertilizer treatment	Yield per acre for years indicated							
	1929	1930	1931	1932	1933	1934	1935	Mean[1]
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Jumbo:								
3-8-3	18.2	15.1	33.0	7.6	0.0	34.3	8.1	16.6
3-8-6	23.2	17.6	33.5	14.1	14.1	41.8	19.7	23.4
3-8-9	31.3	31.3	41.1	9.6	16.1	55.5	19.2	29.3
3-8-12	27.7	32.8	33.0	22.7	14.1	44.4	9.6	26.3
3-8-15	22.7	27.7	33.0	24.7	25.7	38.8	24.7	28.1
Mean	24.6	24.9	34.7	15.7	14.0	43.0	16.2	24.7
No. 1:								
3-8-3	159.3	180.1	74.2	47.0	127.1	127.1	67.2	111.6
3-8-6	161.9	189.6	72.2	64.5	111.9	132.7	70.6	114.7
3-8-9	176.1	178.5	80.3	60.5	121.0	130.1	67.2	116.2
3-8-12	199.7	176.5	80.3	69.6	128.7	155.9	67.6	125.4
3-8-15	185.5	178.5	74.2	57.5	115.6	123.0	69.2	114.7
Mean	176.5	180.6	76.1	59.8	120.8	133.7	68.3	116.3
No. 2:								
3-8-3	27.2	45.4	23.2	43.4	55.5	23.8	38.3	36.7
3-8-6	27.8	46.0	23.8	33.3	59.1	18.2	36.9	34.9
3-8-9	34.3	50.0	25.8	31.3	80.3	20.8	42.4	40.6
3-8-12	23.8	43.0	27.8	32.9	78.2	18.2	32.9	36.6
3-8-15	25.2	36.3	21.8	37.9	40.9	23.8	44.0	32.8
Mean	27.6	44.1	24.4	35.7	62.7	20.9	38.8	36.3
Total:								
3-8-3	204.7	240.6	130.4	98.0	182.6	185.2	113.6	164.9
3-8-6	212.9	253.2	129.5	111.9	185.1	192.7	127.2	173.0
3-8-9	241.7	259.8	147.2	101.4	217.4	206.4	128.8	186.1
3-8-12	251.2	252.3	141.1	125.2	221.0	218.5	110.1	188.3
3-8-15	233.4	242.5	129.0	120.1	182.2	185.6	137.9	175.6
Mean	228.7	249.6	135.2	111.2	197.5	197.6	123.3	177.3

[1] Difference between 7-year means required for significance: Jumbos, 5.5 bushels; No. 1's, 9.7 bushels; No. 2's, 2.5 bushels; total, 11.3 bushels.

TABLE 2.—*Analysis of variance of data for table 1*

Source of variation	Degrees of freedom	Mean squares for grades—			
		Jumbo	No. 1	No. 2	Total
Total	139	259.538	2,739.794	292.566	3,315.146
Between treatments	4	[1] 715.668	763.594	[2] 232.514	[1] 2,637.864
Between tests	6	[1] 2,342.645	[1] 50,632.944	[1] 4,065.820	[1] 59,067.533
Between replicates	3	80.336	[1] 1,385.169	35.432	[2] 1,468.370
Treatments × tests	24	122.298	282.628	[1] 208.510	490.158
Tests × replicates	18	[1] 397.212	[1] 1,952.255	[2] 158.416	[1] 2,113.386
Remainder (error)	84	105.714	332.145	87.853	447.282

[1] Exceeds the 1-percent point.
[2] Exceeds the 5-percent point, but not the 1-percent point.

Table 2 shows that the treatments produced significant differences in yields of Jumbos, of No. 2's, and of total yields, but that the yield of No. 1's was not significantly affected, as judged by comparing treatment variance with remainder variance.

Variation between replicates was rather high within single tests (years) as shown by highly significant *F* values for replicates × tests with reference to remainder. In only the yield of No. 2's was there a significant interaction between treatments and tests. The treatment variances for yields of Jumbos, No. 1's, and total were all very highly significant with reference to treatment × test, indicating consistent responses to treatment over the 7-year period. The very large variances due to test indicate only what one would expect, that yields varied more from year to year than from any other cause.

The magnitude of calculated differences between means required for significance are of particular interest for making comparisons in table 1. In terms of bushels per acre for 7-year means of quadruplicate treatments, they are, for Jumbos, 5.5 bushels; for No. 1's, 9.7 bushels; for No. 2's, 2.5 bushels; and for total yield, 11.3 bushels.

Reference to table 1 will show that on this basis a fertilizer containing 6 to 15 percent potash produced more Jumbos than one containing 3 percent potash and a fertilizer with 9 percent potash produced more than did one with 6 percent. No other differences were significant, although there was a tendency for yields of Jumbos to decrease for percentages of potash beyond 9.

Yields of the No. 1 grade tended to increase gradually from 3-percent up to the 12-percent potash treatments, then dropped for the 15-percent plots. None of these differences was significant.

Although differences in mean yields between treatments in the No. 2 grade were relatively smaller than for the No. 1, some were significant. Fertilizers containing 9 percent of potash produced significantly more than any other treatment, while those with 15 percent produced significantly less than those with 3, 9, or 12 percent of potash.

For total yield, fertilizers with 12 percent potash gave more than those containing 3, 6, or 15 percent, and those with 9 percent yielded significantly more than those with 3 or 6 percent.

Tables 3 and 5 present 4 years' results based on quintuplicate plots of three varieties. The analysis of variance of the data entering into these tables are presented in tables 4 and 6. By virtue, perhaps, of the greatly increased number of degrees of freedom and improved plot size, as well as the experimental area used, the significance of numerous variances was higher than in the analysis of the Porto Rico variety under other conditions. The variances that are significant with reference to residual error are readily noted in tables 4 and 6 so need not be enumerated here. It should be remembered, however, that the plot arrangement was such that tests × replicates in tables 4 and 6 does not indicate a source of error comparable to tests × replicates in table 2; tests × varieties × replicates in tables 4 and 6 indicates block variance within a varietal area for single years (tests) as does tests × replicates in table 2, which latter involves only a single variety.

TABLE 3.—*Effect of increasing potash in fertilizer on total yield of sweetpotatoes per acre, Florence, S. C., 1932–35*

[Plots replicated 5 times]

Variety and fertilizer treatment	Total yield per acre for year indicated				
	1932	1933	1934	1935	Mean [1]
Porto Rico:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
3-8-0	89.1	175.5	164.2	121.0	137.4
3-8-3	95.6	176.7	197.6	105.7	143.9
3-8-6	110.5	183.1	195.2	125.0	153.5
3-8-9	99.2	212.6	202.9	129.9	161.1
3-8-12	117.4	219.8	214.2	111.3	165.7
3-8-15	115.4	179.9	191.6	133.1	155.0
Mean	104.5	191.2	194.2	121.0	152.8
Nancy Hall:					
3-8-0	105.3	207.3	218.6	166.2	174.3
3-8-3	91.2	218.6	243.6	182.7	184.0
3-8-6	85.6	210.6	242.0	175.4	178.4
3-8-9	105.7	185.9	242.0	192.4	181.5
3-8-12	102.0	189.2	249.0	171.4	177.9
3-8-15	109.3	221.8	238.0	157.7	181.7
Mean	99.8	205.5	239.0	174.2	179.6
Big Stem Jersey:					
3-8-0	74.2	164.2	256.9	158.6	163.5
3-8-3	90.8	169.4	275.5	137.9	168.4
3-8-6	75.8	167.4	269.0	136.7	162.2
3-8-9	84.7	162.6	291.6	145.6	171.1
3-8-12	83.2	166.2	289.2	173.8	178.1
3-8-15	96.0	188.6	284.4	142.0	177.7
Mean	84.1	169.6	277.7	149.0	170.2
Summary of 3 varieties:					
3-8-0	89.6	182.3	213.2	148.6	158.4
3-8-3	92.6	188.4	239.0	142.2	165.4
3-8-6	90.6	186.9	235.3	145.6	164.7
3-8-9	96.6	186.9	245.4	156.1	171.3
3-8-12	100.8	191.8	250.7	152.5	173.9
3-8-15	106.9	196.6	238.0	144.4	171.4
Mean	96.2	188.8	237.0	148.2	167.5

[1] Differences between 4-year means required for significance are: For a single variety, 15.8 bushels; for all 3 varieties, 9.1 bushels.

TABLE 4.—*Analysis of variance of data for table 3*

Source of variation	Degrees of freedom	Mean squares	Source of variation	Degrees of freedom	Mean squares
Total	359	3,820.000	Varieties × treatments	10	630.548
Between treatments	5	[1] 1,980.289	Tests × replicates	12	910.653
Between varieties	2	[1] 22,290.541	Tests × treatments	15	616.553
Between tests	3	[1] 322,362.721	Tests × varieties × replicates	24	830.122
Between replicates	4	155.379	Remainder (error)	270	622.589
Varieties × tests	6	[1] 21,550.019			
Varieties × replicates	8	673.254			

[1] Exceeds the 1-percent point.

TABLE 5.—*Effect of increasing potash in fertilizer on yield per acre of sweetpotatoes in each United States grade, Florence, S. C., 1932–35*

[Plots replicated 5 times]

Variety and fertilizer treatment	1932			1933			1934			1935			Mean[1]		
	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2
Porto Rico:	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
3-8-0	14.5	45.2	29.4	4.4	107.7	63.3	33.1	112.6	18.6	10.9	71.0	39.1	15.7	84.1	37.6
3-8-3	11.7	44.8	39.1	.0	122.2	54.4	32.3	138.7	26.6	8.5	61.7	35.5	13.1	91.9	38.9
3-8-6	18.6	59.3	32.7	11.3	112.5	59.3	37.5	135.1	22.6	19.8	67.4	37.9	21.8	93.6	38.1
3-8-9	14.1	56.1	29.0	12.9	120.2	79.5	47.2	133.1	22.6	22.6	66.6	40.7	24.2	94.0	43.0
3-8-12	23.0	64.5	29.8	13.3	128.3	78.2	43.6	151.7	19.0	12.1	68.2	31.1	23.0	103.2	40.0
3-8-15	28.2	52.8	34.3	20.6	117.0	42.3	40.3	127.5	23.8	24.2	66.6	42.4	28.3	91.0	35.7
Mean	18.4	53.8	32.4	10.4	117.8	62.9	39.0	133.1	22.2	16.3	66.9	37.8	21.0	92.9	38.8
Nancy Hall:															
3-8-0	16.9	55.7	32.7	.0	133.9	73.4	33.5	153.3	31.9	31.5	87.9	46.8	20.5	107.7	46.2
3-8-3	13.3	49.6	28.2	.0	143.2	75.4	23.0	177.9	42.8	35.5	99.2	48.0	17.9	117.5	48.6
3-8-6	19.0	43.6	23.0	.0	140.4	70.2	44.4	158.9	38.7	35.5	95.6	44.4	24.7	109.6	44.1
3-8-9	18.2	58.5	28.6	.0	116.2	69.8	39.1	166.2	36.7	50.8	87.9	53.6	27.0	107.2	47.3
3-8-12	22.2	54.9	25.0	.0	122.2	67.0	32.7	180.3	35.9	48.4	82.3	40.7	25.8	109.9	42.1
3-8-15	17.7	63.7	27.8	.0	144.4	77.4	33.9	167.0	37.1	35.5	77.8	44.4	21.8	113.4	46.7
Mean	17.9	54.3	27.6	.0	133.2	72.2	34.4	167.2	37.2	39.6	88.5	46.3	23.0	110.8	45.8
Big Stem Jersey:															
3-8-0	2.0	35.1	37.1	.0	106.9	57.3	2.8	215.0	39.1	18.6	77.0	62.9	5.8	108.5	49.1
3-8-3	2.4	49.6	38.7	.0	109.3	60.0	.0	225.9	49.6	16.1	67.0	54.9	4.6	112.9	50.8
3-8-6	2.4	31.0	42.4	.0	108.5	58.9	.0	226.3	42.8	9.7	71.8	55.3	3.0	109.4	49.8
3-8-9	2.8	40.3	41.6	.0	106.1	56.5	13.3	227.9	50.4	12.9	79.9	52.8	7.3	113.5	50.3
3-8-12	5.2	38.7	39.1	.0	105.7	60.5	2.8	238.0	48.4	16.9	93.2	63.7	6.3	118.9	52.9
3-8-15	6.9	48.0	41.1	.0	108.9	79.5	5.2	231.1	48.0	19.8	79.5	42.8	8.0	116.9	52.8
Mean	3.6	40.5	40.0	.0	107.6	62.1	4.0	227.3	46.4	15.7	78.0	55.4	5.8	113.4	51.0
Summary of 3 varieties:															
3-8-0	11.1	45.4	33.1	1.4	116.2	64.7	23.2	160.3	29.8	20.4	78.7	49.6	14.0	100.1	44.3
3-8-3	9.1	48.0	35.3	.0	124.8	63.3	18.4	180.9	39.7	20.0	76.0	46.2	11.9	107.4	46.1
3-8-6	13.3	44.6	32.7	3.8	120.4	62.7	27.2	173.4	34.7	21.6	78.2	45.8	16.5	104.2	44.0
3-8-9	11.7	51.6	33.3	4.3	114.1	68.6	33.3	175.9	36.5	28.8	78.0	49.0	19.5	104.9	46.8
3-8-12	16.7	52.6	31.3	4.4	118.8	68.6	26.4	190.0	34.5	25.8	81.3	45.2	18.4	110.7	44.9
3-8-15	17.5	54.9	34.5	6.9	123.4	66.3	26.5	175.3	36.3	26.4	74.6	43.2	19.4	107.0	45.1
Mean	13.3	49.5	33.3	3.5	119.6	65.7	25.8	175.9	35.3	23.8	77.8	46.5	16.6	105.7	45.2

[1] Differences required for significance between 4-year means are: For a single variety—Jumbos, 6.3 bushels; No. 1's, 7.9 bushels; No. 2's, 6.7 bushels. For all 3 varieties—Jumbos, 3.7 bushels; No. 1's, 4.6 bushels; No. 2's, 3.8 bushels.

TABLE 6.—*Analysis of variance of data for table 5*

Source of variation	Degrees of freedom	Mean squares for grade—		
		Jumbo	No. 1	No. 2
Total	359	316.568	2,922.515	332.790
Between treatments	5	[1] 616.909	[1] 675.539	71.456
Between varieties	2	[1] 10,554.307	[1] 14,883.149	[1] 4,476.814
Between tests	3	[1] 9,618.642	[1] 271,705.645	[1] 19,874.410
Between replicates	4	107.619	228.304	15.093
Varieties × tests	6	[1] 3,000.386	[1] 21,272.754	[1] 1,487.271
Varieties × replicates	8	135.920	[1] 657.635	92.123
Varieties × treatments	10	164.221	[2] 355.860	102.874
Tests × replicates	12	[1] 386.109	[1] 362.804	[2] 198.089
Tests × treatments	15	65.697	[1] 447.262	100.480
Tests × varieties × replicates	24	[1] 277.156	[1] 435.000	[1] 250.817
Remainder (error)	270	100.689	155.741	110.681

[1] Exceeds the 1-percent point.

[2] Exceeds the 5-percent point but not the 1-percent point.

The major differences between the results of the 4 years' tests of three varieties and of the 7 years' tests of one variety are:

In the three-variety test, treatment variances for Jumbos, No. 1's, and total yield were significant, while in the one-variety test they were significant for Jumbos, No. 2's, and total.

Variances due to varieties (variety and varietal area) and to varieties × tests are all highly significant in tables 3 to 6, although they did not enter into table 2.

For total yield, variance due to test × variety × replication in the three-variety analysis was quite insignificant, while in the single-variety study it was highly significant.

The calculated differences necessary for significance between 4-year mean total yields of quintuplicate plots of treatments are (see table 3 for total yields) for a single variety, 15.8 bushels; for all three varieties, 9.1 bushels. Corresponding values for each of the three grades as shown in table 5 are for a single variety—Jumbos, 6.3 bushels; No. 1's, 7.9 bushels; No. 2's, 6.7 bushels. For all three varieties—Jumbos, 3.7 bushels; No. 1's, 4.6 bushels; No. 2's, 3.8 bushels.

There should first be noted in table 3 a consistent tendency in all varieties singly and combined for increasing amounts of potash up to 9 or 12 percent to increase yields with a slight decrease beyond 12 percent.

In the Porto Rico variety all percentages of potash in the fertilizer mixtures except 3 produced a significantly higher total yield than no potash, and the mixture with 3 percent was outyielded significantly by that with 9 and 12 percent. Despite the general tendency noted, the yield differences among the treatments containing 6 to 15 percent of potash are insignificant for this variety. There were no significant total yield differences within the Nancy Hall variety alone, and only one significant difference within the Big Stem Jersey—between fertilizers containing 6 and 12 percent of potash. This general lack of significance within varieties is a bit surprising but should not be taken as proof that potash is not needed under these conditions. The tendency to respond is fairly well marked in the means of treatments, but is disturbed by various unidentified factors that result in high variance for error and comparatively few statistically significant differences.

When all varieties are considered together, the no-potash plots are significantly outyielded by fertilizers containing 9, 12, and 15 percent potash.

Although the Porto Rico is the most extensively cultivated variety in South Carolina, these tests suggest that Nancy Hall might well be given more attention. It outyielded Porto Rico by 26.8 bushels per acre, a relative increase of 17.5 percent on the basis of total yield and 17.9 bushels or 19.3 percent of No. 1's.

The most striking fact evident in table 5 is that there are no significant differences in yields of No. 2 grade due to treatment within single or combined varieties. The mean yields of No. 2 are remarkably constant. Such differences in total yield due to treatment as appear in table 3 are therefore chiefly the result of differences in the Jumbo and No. 1 grades. The Big Stem Jersey variety produced such small and nearly constant 4-year mean yields of Jumbos that they require no further consideration. The production of few Jumbos is a characteristic of the variety.

Within the Porto Rico and Nancy Hall varieties there was no significant difference in yield of Jumbos among the fertilizers with 6 to 15 percent potash, but in general these outyielded the fertilizers with 0 to 3 percent potash.

It is of interest in table 5 that there is both a greater absolute and relative increase in mean yield of No. 1's of Porto Rico from increased potash than in either of the other two varieties. Furthermore, table 6 shows this interaction between variety and treatment to be significant. The variance due to this interaction, however, is not significantly smaller than that due to treatment alone, so it seems clear that in these studies some variety or varieties definitely failed to respond significantly to treatment, while others did respond. No significant differences occurred within the Nancy Hall variety. In the Big Stem Jersey only the fertilizers containing 12 and 15 percent potash significantly outyielded the no-potash treatment, and there were insignificant differences among the fertilizers with 3, 9, 12, and 15 percent potash. Thus, a new question is presented to sweetpotato growers and investigators: To what extent may varietal differences in reaction to potash justify specific recommendations and treatments on a variety or variety-group basis? Obviously, the question cannot now be answered, and will probably remain an academic one for a long time.

Turning now to the figures for all varieties combined, fertilizers containing 9 to 15 percent of potash produced more Jumbos than those with 0 or 3, and those with 6 percent outyielded those with 3 percent potash. In yield of No. 1's all fertilizers but those with 6 percent potash outyielded no potash, and among these, only those with 12 percent potash outyielded any of the others.

GRADES IN PERCENTAGE OF TOTAL YIELD

The data for yield per acre of each of the three United States grades summarized in tables 1 and 5 have been calculated in terms of percent of total yield and are presented in tables 7 and 9, and the analyses of variance of these data are shown in tables 8 and 10. It should be emphasized that these figures are presented to show mean tendencies for the several plots, treatments, varieties, and years, regardless of the magnitude of the yield. In other words, the means shown are unweighted means obtained by averaging the respective percentages instead of calculating percentages of total yields for groups of plots, treatments, etc.

Table 7.—*Effect of increasing potash in fertilizer on percentage of total yield of Porto Rico sweetpotatoes in each United States grade, Florence, S. C., 1929–35*

[Plots replicated 4 times]

Grade and fertilizer treatment	1929	1930	1931	1932	1933	1934	1935	Mean[1]
Jumbo:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
3-8-3	8.5	6.5	25.0	6.3	0.0	17.8	7.8	10.26
3-8-6	10.8	7.3	25.8	12.0	7.3	20.8	15.0	14.12
3-8-9	12.8	12.5	28.0	8.5	6.8	26.8	14.8	15.70
3-8-12	11.5	13.0	23.8	18.0	6.8	20.5	9.0	14.64
3-8-15	9.5	11.5	26.3	19.3	13.3	21.5	17.8	17.08
Mean	10.6	10.1	25.8	12.8	6.8	21.4	12.8	14.37
No. 1:								
3-8-3	77.8	73.8	56.5	49.3	69.5	69.0	58.8	64.96
3-8-6	76.0	74.0	55.5	57.0	60.5	68.8	56.3	64.04
3-8-9	72.8	68.0	54.3	60.0	56.5	63.0	51.8	60.85
3-8-12	79.5	69.5	56.3	55.8	58.3	71.5	60.8	64.50
3-8-15	78.8	73.3	56.5	49.5	64.3	65.3	50.3	62.64
Mean	76.9	71.7	55.8	54.3	61.8	67.5	55.5	63.39
No. 2:								
3-8-3	13.5	19.8	18.3	44.5	30.5	13.3	33.5	24.76
3-8-6	13.3	18.8	18.3	31.0	32.3	10.5	28.8	21.83
3-8-9	14.5	19.5	18.3	31.5	36.8	10.3	33.5	23.45
3-8-12	9.3	17.3	20.0	26.3	35.0	8.0	30.3	20.86
3-8-15	11.0	15.3	16.5	31.3	22.5	13.3	32.0	20.26
Mean	12.3	18.1	18.2	32.9	31.4	11.0	31.6	22.23

[1] Differences between 7-year means required for significance are: Jumbos, 3 percent; No. 2's, 2.8 percent.

Table 8.—*Analysis of variance of data for table 7*

Source of variation	Degrees of freedom	Mean squares for grade—		
		Jumbo	No. 1	No. 2
Total	139	87.138	115.501	116.016
Between treatments	4	[1] 273.554	76.547	[2] 96.921
Between tests	6	[1] 920.057	[1] 1,580.164	[1] 1,807.431
Between replicates	3	26.181	46.724	7.524
Replicates × tests	18	[1] 127.025	[2] 84.205	[1] 78.952
Treatments × tests	24	20.045	51.667	[2] 47.996
Remainder (error)	84	31.556	40.131	27.508

[1] Exceeds 1-percent point.

[2] Exceeds 5-percent point but not the 1-percent point.

TABLE 9.—*Effect of increasing potash in fertilizer on percentage of total yield of sweetpotatoes in each United States grade, Florence, S. C., 1932–35*

[Plots replicated 5 times]

Variety and fertilizer treatment	1932			1933			1934			1935			Mean[1]		
	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2	Jumbo	No. 1	No. 2
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Porto Rico:															
3-8-0	16.6	50.0	33.4	2.4	61.8	35.8	19.8	68.8	11.4	8.8	59.0	32.2	11.9	59.9	28.2
3-8-3	12.4	47.8	40.8	.0	69.0	31.0	16.2	70.2	13.6	9.0	57.8	33.2	9.1	61.2	29.7
3-8-6	16.0	52.4	30.6	5.8	61.6	32.6	18.6	69.0	12.4	15.4	54.4	30.2	14.1	59.4	26.5
3-8-9	14.0	56.4	29.6	5.4	57.2	37.4	22.8	65.8	11.4	17.2	51.0	31.8	14.9	57.6	27.5
3-8-12	20.0	54.8	25.2	6.2	58.6	35.2	20.4	71.0	8.6	11.0	60.6	28.4	14.4	61.2	24.4
3-8-15	24.2	46.6	29.2	10.6	65.8	23.6	21.6	65.6	12.8	18.0	50.0	32.0	18.6	57.0	24.4
Mean	17.1	51.4	31.5	5.1	62.3	32.6	19.9	68.4	11.7	13.2	55.5	31.3	13.8	59.4	26.8
Nancy Hall:															
3-8-0	15.2	53.6	31.2	.8	64.8	35.2	15.0	70.2	14.8	19.2	53.0	27.8	12.3	60.4	27.3
3-8-3	13.8	54.8	31.4	.0	65.6	34.4	9.4	73.4	17.2	19.6	54.2	26.2	10.7	62.0	27.3
3-8-6	22.0	50.9	27.1	.0	66.6	33.4	19.0	65.0	16.0	20.2	54.4	25.4	15.3	59.2	25.5
3-8-9	15.4	55.8	28.8	.0	62.6	37.4	15.8	69.0	15.2	25.4	46.0	28.6	14.1	58.3	27.5
3-8-12	20.4	54.5	25.1	.0	64.4	35.6	13.0	72.8	14.2	28.0	48.0	24.0	15.3	59.9	24.8
3-8-15	16.8	56.6	26.6	.0	65.2	34.8	14.6	69.8	15.6	22.0	49.4	28.6	13.3	60.2	26.4
Mean	17.3	54.3	28.4	.0	64.9	35.1	14.5	70.0	15.5	22.4	50.8	26.8	13.5	60.0	26.4
Big Stem Jersey:															
3-8-0	2.4	47.0	50.6	.0	65.8	34.2	1.2	83.2	15.6	11.6	48.0	40.4	3.8	61.0	35.2
3-8-3	2.0	53.4	44.6	.0	64.6	35.4	.0	82.4	17.6	12.8	48.4	38.8	3.7	62.2	34.1
3-8-6	3.0	40.6	56.4	.0	64.8	35.2	.0	84.2	15.8	7.8	52.8	39.4	2.7	60.6	36.7
3-8-9	2.8	47.6	49.6	.0	65.6	34.4	4.4	78.4	17.2	9.4	54.8	35.8	4.1	61.6	34.3
3-8-12	6.2	47.0	46.8	.0	63.6	36.4	.8	82.4	16.8	9.6	53.6	36.8	4.1	61.6	34.2
3-8-15	7.0	49.6	43.4	.0	57.8	42.2	2.0	81.2	16.8	14.0	55.4	30.6	5.7	61.0	33.3
Mean	3.9	47.5	48.6	.0	63.7	36.3	1.4	82.0	16.6	10.9	52.2	37.0	4.0	61.4	34.6
Mean of 3 varieties:															
3-8-0	11.4	50.2	38.4	.8	64.1	35.1	12.0	74.1	13.9	13.2	53.4	33.4	9.3	59.8	30.2
3-8-3	9.1	52.0	38.9	.0	66.4	33.6	8.5	75.4	16.1	13.8	53.5	32.7	7.8	61.8	30.4
3-8-6	13.9	48.0	38.1	1.9	64.4	33.7	12.5	72.8	14.7	14.5	53.8	31.7	10.7	59.8	29.5
3-8-9	10.7	53.3	36.0	1.8	61.8	36.4	14.3	71.1	14.6	17.3	50.6	32.1	11.1	59.1	29.8
3-8-12	15.5	52.1	32.4	2.1	62.2	35.7	11.4	75.4	13.2	16.2	54.1	29.7	11.3	60.9	27.8
3-8-15	16.0	50.9	33.1	3.5	63.0	33.5	12.7	72.2	15.1	18.0	51.6	30.4	12.6	59.4	28.0
Mean	12.8	51.0	36.2	1.7	63.6	34.7	11.9	73.5	14.6	15.6	52.7	31.7	10.5	60.2	29.3

[1] Difference between 4-year means of Jumbos required for significance is 3.3 percent for a single variety, 1.9 percent for all 3 varieties.

TABLE 10.—*Analysis of variance of data for table 9*

Source of variation	Degrees of freedom	Mean squares for grade—		
		Jumbo	No. 1	No. 2
Total	359	105.910	134.515	135.900
Between treatments	5	[1] 163.116	59.823	74,617
Between varieties	2	[1] 3,721.169	[2] 118,119	[1] 2,568.344
Between tests	3	[1] 3,293.773	[1] 9,756.751	[1] 8,915.467
Between replicates	4	[2] 72.607	44.543	51.326
Varieties × tests	6	[1] 710.118	[1] 698.468	[1] 688.466
Varieties × replicates	8	[2] 60.071	39.473	43.528
Varieties × treatments	10	[2] 60.439	20.465	35.504
Tests × replicates	12	[1] 174.813	[1] 122.202	[1] 84.451
Tests × treatments	15	29.855	36.069	37.667
Tests × varieties × replicates	24	[1] 177.475	47.700	[1] 77.253
Remainder (error)	270	27.561	42.920	36.756

[1] Exceeds the 1-percent point. [2] Exceeds the 5-percent point but not the 1-percent point.

It may properly be argued from one point of view that this method of treating the data gives an exaggerated or disproportionate value or importance to the grade distributions occurring in years of low yield.

The writers believe, however, that this method of treatment is justified here on account of the generally higher value per bushel of the crop in years of low yield. A high percentage of Jumbos or No. 2's and a low percentage of No. 1's may often be of relatively more economic importance in years of low total yield than in years of high total yield. In these studies the high-yielding years produced consistently and appreciably higher percentages as well as actual yields of No. 1's. There is ample basis for subjecting these tables of percentages to analysis by the variance method to reveal mean tendencies, although the magnitudes upon which the percentages are based differ quite widely. (See Snedecor *10, pp. 21–28.*)

It is readily seen in the last column of table 7 and the last three columns of table 9 that there is a fairly consistent tendency for the percentage of Jumbos to increase and the No. 2's to decrease slightly with increase in percentage of potash in the fertilizer. Differences in percentage of No. 1's were relatively smaller and showed no definite trend in relation to potash.

Table 8 shows that the variances in percentage of Jumbos and No. 2's (table 7) due to treatment are significant with reference to remainder error, but that of the No. 1 grade is not significant. Table 10 shows that in table 9 only the Jumbo grade showed a significant variance due to treatment.

The required magnitudes of differences for significance between 7-year means of quadruplicate plots (table 7) are for Jumbos, 3 percent and for No. 2's, 2.8 percent. Thus, fertilizers with 6 to 15 percent potash generally produced a larger proportion of Jumbos in the Porto Rico variety than did the fertilizers having 3 percent potash, and there were no significant differences among the results from fertilizers with 6 to 15 percent potash. However, the difference between the yields from fertilizers with 6 and 15 percent potash closely approached significance. With reference to the No. 2 grade, fertilizers containing 12 and 15 percent of potash produced a significantly smaller proportion of this grade than those with 3 or 9 percent potash.

It will be recalled that in table 9 significant differences due to treatment occurred only in the percentage of Jumbos. The differences due to treatment in the remaining portions of the respective plots were so irregularly divided between No. 1's and No. 2's that neither of these grades alone showed a variance significant with reference to error. The magnitudes of differences required for significance between 4-year means of quintuplicate plots for Jumbos are calculated to be for a single variety, 3.3 percent; for three varieties combined, 1.9 percent. On this basis the fertilizers with 6 to 15 percent potash produced a greater proportion of Jumbos in the Porto Rico than did those with 3 percent; and those with 15 percent potash more than those with 0 to 12 percent. The Nancy Hall variety showed less striking differences; only the fertilizers with 6 to 12 percent potash produced a significantly greater proportion of Jumbos than those with 3 percent, and there were no other significant differences. In all three varieties combined there was a slight but insignificant tendency (3 years out of 4) for the fertilizer with 3 percent of potash to produce a smaller proportion of Jumbos than those with no potash. The reason for this is not clear.

For all varieties combined, the fertilizers with 12 and 15 percent potash produced on the average a greater proportion of Jumbos than those with no potash, and the fertilizers with 6 to 15 percent potash more than those with 3 percent. There were no significant differences among the plots with 6 to 15 percent potash.

Variances in proportion of Jumbos due to treatment are significant with reference to treatments × tests in tables 8 and 10, indicating consistent responses year after year.

Response to treatment varied significantly, however, between varieties (varieties × treatments compared with remainder error); in fact, Big Stem Jersey showed no significant differences whatever in grade distribution in response to treatment.

MEAN SIZE OF ROOTS

Each lot of roots measured for shape was weighed as a unit at the time of measurement, usually in January, after 2 to 3 months of storage. The figures in table 11 show the mean root weights for quintuplicate lots of the fertilizer plots with 3 and 15 percent potash for three varieties for 4 years. Even a casual inspection of these figures shows the lack of any appreciable and consistent difference in mean size that can be ascribed to fertilizer treatment. It is not surprising that the mean sizes of the No. 1 and No. 2 grades were without consistent differences within grades since the grading procedure largely involves stratification on the basis of size. However, in view of the significant differences in yield and grade distribution demonstrated in previous sections (pp. 6–16), it was rather unexpected that the mean sizes for the grand total of each treatment should happen to be so nearly identical.

TABLE 11.—*Effect of increasing potash in fertilizer on mean size of sweetpotatoes produced, Florence, S. C., 1932–35*

Variety and year	Weight of sweetpotatoes of grade and percentage of K_2O in fertilizer indicated							
	Jumbo		No. 1		No. 2		Total yield	
	3 percent	15 percent	3 percent	15 percent	3 percent	15 percent	3 percent	15 percent
Porto Rico:	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
1932	1.115	1.945	0.476	0.512	0.385	0.356	0.464	0.539
1933	----------	2.122	.851	.734	.366	.259	.604	.542
1934	1.568	1.695	.732	.708	.230	.240	.606	.632
1935	(?)	1.250	.665	.469	.204	.210	.332	.366
Mean	1.141	1.681	.659	.622	.288	.255	.504	.512
Nancy Hall:								
1932	1.320	1.128	.423	.498	.370	.271	.458	.443
1933	----------	----------	.721	.732	.397	.457	.562	.605
1934	1.460	1.334	.784	.725	.403	.387	.698	.687
1935	1.955	1.313	.580	.627	.322	.266	.539	.489
Mean	1.631	1.277	.659	.666	.372	.349	.575	.566
Big Stem Jersey:								
1932	2.000	1.308	.498	.478	.412	.318	.466	.408
1933	----------	----------	.692	.556	.398	.458	.548	.510
1934	----------	1.625	.816	.872	.374	.353	.672	.703
1935	1.110	1.361	.520	.648	.274	.294	.401	.503
Mean	1.179	1.385	.681	.683	.352	.362	.536	.550
Mean of 3 varieties	1.366	1.465	.666	.659	.338	.322	.540	.543

SHAPE OF ROOTS

Although the question of effect of potash on shape of root was a primary one underlying these studies, and although the collection and calculation of data on shape constituted the most laborious part of the work, the results can be most briefly presented and require but few words of discussion. Facilities were not at hand for obtaining shape indexes for all treatments in the study. Since there was also doubt of the necessity of measuring roots from all treatments, in order to determine the effect of increased potash on shape, only the roots from the extreme potash treatments were measured—viz, those with fertilizers having 3 and 15 percent potash.

Table 12 presents mean shape indexes with their probable errors for the Porto Rico variety for 1929–31. It will be noted that in 1929 the high-potash treatments produced the higher shape indexes in each grade—longer, more slender roots in proportion to diameter—quite contrary to expectations based on the literature. In 1930 the high-potash plots had a larger index for Jumbos and insignificantly smaller indexes for No. 1's and No. 2's. In 1931 high potash produced significantly smaller indexes—thicker roots in proportion to length—than low potash for all three grades.

TABLE 12.—*Effect of different amounts of potash in fertilizer upon shape indexes of Porto Rico sweetpotatoes, Florence, S. C., 1929–31*

Year	K_2O in fertilizer	Jumbo	No. 1	No. 2
	Percent	*Index* [1]	*Index* [1]	*Index* [1]
1929	3	1.733±0.0257	1.615±0.0112	2.174±0.0222
	15	1.770± .0259	1.876± .0123	2.341± .0262
1930	3	1.654± .0187	1.911± .0149	2.345± .0165
	15	2.267± .0316	1.886± .0134	2.341± .0190
1931	3	1.641± .0306	1.624± .0087	1.971± .0142
	15	1.478± .0219	1.508± .0112	1.594± .0155
Mean	3	1.684± .0141		
	15	1.828± .0173		

[1] Shape index $= \frac{\text{Length}}{\text{Diameter}}$ (see p. 6).

Table 13 presents indexes and their probable errors for three varieties for the years 1932–35. The entire yield of each grade from each plot in those years was measured so that properly weighted mean indexes for total yields, for totals of years, varieties, or treatments can be shown. It will be seen that with few exceptions high potash produced a lower shape index than did low potash. In a large number of cases these differences are insignificant (less than three times the probable error of the difference).

Table 13.—*Effect of different amounts of potash in fertilizer upon shape indexes of sweetpotatoes, Florence, S. C., 1932–35*

Variety and year	K_2O in fertilizer	Jumbo	No. 1	No. 2	Total crop
	Percent	*Index* [1]	*Index* [1]	*Index* [1]	*Index* [1]
Porto Rico:					
1932	3	2.238±0.0990	2.355±0.0334	3.105±0.0465	2.719±0.0303
	15	1.856± .0826	2.013± .0219	2.424± .0339	2.177± .0199
1933	3	----------------	2.240± .0241	3.122± .0367	2.689± .0247
	15	1.970± .0832	2.217± .0184	2.896± .0735	2.543± .0235
1934	3	1.464± .0553	1.923± .0136	2.849± .0483	2.238± .0215
	15	1.523± .0403	1.794± .0129	2.864± .0370	2.126± .0179
1935	3	1.948± .0492	2.336± .0214	3.004± .0271	2.619± .0200
	15	1.824± .0214	2.142± .0224	2.834± .0260	2.566± .0196
4-year mean	3	1.947± .0388	2.175± .0116	2.979± .0192	2.546± .0120
	15	1.741± .0272	2.072± .0103	2.782± .0182	2.382± .0109
Nancy Hall:					
1932	3	2.171± .1160	2.426± .0256	2.723± .0452	2.524± .0195
	15	1.863± .0507	2.079± .0204	2.422± .0319	2.208± .0181
1933	3	----------------	2.422± .0171	3.075± .0280	2.742± .0177
	15	----------------	2.405± .0167	2.913± .0281	2.640± .0167
1934	3	1.486± .0299	1.949± .0127	3.409± .0042	2.377± .0231
	15	1.540± .0294	1.895± .0130	3.086± .0425	2.232± .0213
1935	3	1.963± .0507	2.479± .0165	3.028± .0293	2.575± .0199
	15	2.064± .0473	2.314± .0191	3.290± .0396	2.605± .0227
4- year mean	3	1.770± .0362	2.230± .0097	3.072± .0186	2.555± .0107
	15	1.704± .0243	2.163± .0096	2.877± .0181	2.436± .0103
Big Stem Jersey:					
1932	3	3.093± .0491	2.717± .0464	3.636± .0611	3.292± .0358
	15	1.985± .0771	2.501± .0287	2.923± .0374	2.722± .0250
1933	3	----------------	2.513± .0183	2.884± .0338	2.668± .0202
	15	----------------	2.319± .0177	2.790± .0278	2.540± .0168
1934	3	----------------	2.060± .0126	2.923± .0353	2.345± .0181
	15	1.759± .1393	2.033± .0118	3.101± .0360	2.420± .0197
1935	3	1.786± .0375	2.252± .0180	2.942± .0298	2.783± .0212
	15	1.781± .0277	2.336± .0225	2.990± .0330	2.828± .0234
4-year mean	3	2.108± .0639	2.387± .0112	3.069± .0194	2.697± .0116
	15	2.009± .0515	2.244± .0097	3.037± .0185	2.598± .0109
Summary of 3 varieties:					
1932	3	2.254± .0765	2.578± .0203	3.181± .0315	2.837± .0182
	15	1.816± .0465	2.186± .0144	2.620± .0211	2.372± .0129
1933	3	----------------	2.398± .0115	3.030± .0182	2.711± .0115
	15	1.970± .0850	2.320± .0101	2.866± .0188	2.576± .0110
1934	3	1.648± .0346	1.987± .0085	3.050± .0254	2.323± .0120
	15	1.566± .0283	1.944± .0084	3.094± .0250	2.272± .0119
1935	3	2.077± .0286	2.345± .0123	2.971± .0184	2.660± .0118
	15	1.870± .0247	2.308± .0136	3.013± .0198	2.656± .0132
4-year mean	3	1.892± .0248	2.268± .0063	3.041± .0110	2.601± .0020
	15	1.764± .0176	2.164± .0057	2.901± .0106	2.474± .0062

[1] Shape index $= \frac{\text{Length}}{\text{Diameter}}$ (see p. 6).

Although the differences between 4-year means of treatments within a variety were very small in all cases, they were generally significant statistically. High potash generally produced the lower index but not always. The Porto Rico variety appeared to respond relatively more to potash, as measured by change in shape, than did either Nancy Hall or Big Stem Jersey, but to a degree of very doubtful importance. In fact, it would seem that only in 1932 was there sufficient difference in shape indexes due to treatment to be of any practical importance, or even detectable by the eye. In the summary of the three varieties shown at the bottom of table 13 there are only two instances in which high potash was accompanied by a higher index of a single grade than was low potash, and in no case did this occur for the total of the three grades. Such differences between treatments as were statistically significant would be unrecognizable in practice, with the possible exception of the 1932 crop.[5] The mean indexes for the grand totals of the two treatments were 2.601±0.0020 and 2.474±0.0062 for low and high potash, respectively, presenting a statistically significant difference of no practical importance.

DISCUSSION

The moderate effect upon yields and the unimportant effects of potash in general in these studies have surprised many persons who have had occasion to study the data. The opinion that sweetpotatoes always require large quantities of potash on Coastal Plain soils has become so prevalent that the authors, as well as others, have been inclined to question whether differences in method or varieties might account for the rather striking disagreement of these results with those obtained by other workers in the Atlantic States.

In these studies only 500 pounds per acre of fertilizer was used, representing 15 to 75 pounds of K_2O, or about 30 to 150 pounds of muriate of potash per acre. Schermerhorn (*7*) used 1,200 to 1,400 pounds per acre of mixtures running as high as 12 percent of potash; however, he recommends no more than 8 percent of potash, or the equivalent, about 100 pounds of K_2O per acre. Some of his better yields in his triangle studies were obtained with mixtures containing but 60 to 80 pounds of K_2O. Marked differences in shape and grade of roots were obtained with 1,400 pounds of 3–8–0 versus 3–8–4, the latter supplying 56 pounds of K_2O per acre. Yields were 24 and 101 bushels of No. 1's, respectively.

Zimmerley (*12*) applied 1,000 pounds per acre of each of his triangle mixtures, the 3–3–15 mixture supplying 150 pounds of K_2O, and he recommends 30 pounds of nitrogen, 30 pounds of phosphoric acid, and 150 pounds of potash per acre. His treatments supplying but 60 to 90 pounds of K_2O yielded 250 to 260 bushels, while those supplying 120 to 150 pounds yielded 270 to 290 bushels per acre.

Geise (*3*) obtained some phenomenal increases in yield from 100 pounds of K_2O per acre.

Schermerhorn (*7*) worked with the Yellow Jersey and Zimmerley (*12*) and Geise (*3*) with Big Stem Jersey. The authors included Big Stem Jersey in 4 years of the present work.

Thus, although there are marked differences in method among these various studies in the Atlantic States, there are some bases for comparison. The divergence of results cannot be accounted for on the basis either of variety used or amount of potash applied. It appears that the South Carolina soils where the present studies were conducted have no such severe deficiency of potash as those of the New Jersey and Maryland soils cited. It can hardly be argued that the South Carolina soils were seriously deficient in either nitrogen or phosphoric acid, for yields of 150 to 200 bushels of U. S. No. 1's (obtained in years of normal rainfall) from plots treated with 500 pounds of 3–8–0 are fair yields.

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[5] This difference due to treatment was not noticed in handling the 1932 crop. It became evident only upon analysis of shape indexes.

It is interesting to note that results reported from the South Atlantic and Gulf States in general show less marked response to potash than those from the Middle Atlantic coastal areas. Referring again to the work of Skinner, Williams, and Mann in North Carolina (*9*), it is found that in the potash comparisons 750 or 1,400 pounds per acre of fertilizer mixtures containing 6 to 9 percent of potash gave higher yields than those with 12 or 15 percent, and in most cases the increases amounted to only 10 to 30 percent over the no-potash treatments. The poor results from the highest potash mixtures were due in part to loss of stand from too much fertilizer in close proximity to newly set plants. Although the system of treatments used by these workers was quite different from that of the present study, the results are similar insofar as response to potash is concerned.

The results obtained in Georgia by Woodard (*11*) are more in conformity with the New Jersey, Maryland, and Virginia work than with that in the Carolinas. Eight hundred pounds per acre of a 4–8–6 mixture gave double the No. 1 yield produced by a 4–8–0 (150 versus 70 bushels per acre) and an increase of about 75 percent in total yield. The Georgia results are in conformity with those of several other investigators in that percentages of potash above 6 (more than 50 pounds of K_2O per acre) produce either no further increases in yield, or increases of doubtful significance. Woodard's results showed a consistent increase in percentage of Jumbo and No. 1 grades, whereas the present work showed a consistent statistically significant change only in the Jumbos.

It is rather surprising that the present results in South Carolina on sandy loam soils should be so similar to those of the potash series of treatments conducted in Louisiana on a silt loam soil by Miller and Kimbrough (*5*).

Only Schermerhorn (*6*, *7*) had previously reported shape index data in relation to response to potash. The dearth of such data from important sweetpotato regions was a major reason for outlining the present investigation. The striking lack of agreement between the results of these studies and Schermerhorn's first suggested that the soils used contained unusually high residues of previously applied potash-carrying fertilizer, so after 3 years the plots were moved to other fields that were known to have had no appreciable amount of fertilizer for many years and that were considered unproductive. Although variable weather produced wide differences between years, it seems that the latter soil was probably distinctly less fertile than that used the first 3 years. The mean total yield of five treatments on Porto Rico was 205 bushels per acre the first 3, and 158 bushels the last 4 years. However, despite the lower fertility there still appears to be no more marked response to potash on this soil.

It was thought possible that the authors might have measured a different range of root sizes than Schermerhorn did, but recent inquiry shows that both measured everything but "strings."

Difference in varietal response was another possible explanation of marked differences in shape response in the New Jersey and South Carolina studies. Although the authors at no time included Yellow

Jersey—used by Schermerhorn—Big Stem Jersey, a closely related variety, was included. At first it was believed that the lack of shape response might be due partly to a varietal characteristic of the Porto Rico, which was used alone in the first 3 years' work. Later, however, it was found (see table 11) that Porto Rico tended to be more responsive to potash than did the Big Stem Jersey, supposedly more closely related to the Yellow Jersey. There is still the possibility that varietal differences are of major importance in explaining the disagreement of results, but it is believed highly improbable in the present case. One of the writers informally assisted Geise (*3*) in his work in Maryland and observed a tendency under some conditions for the Big Stem Jersey to react to potash as Schermerhorn (*6*, *7*) has reported for Yellow Jersey.

It thus appears definite that the South Carolina soils on which these present studies were conducted are not especially deficient in potash for the growing of sweetpotatoes, that this crop responds in only a moderate degree to potash applications up to 50 to 60 pounds per acre of K_2O on these soils, and that potash applications to such soils are without important effect on shape of sweetpotatoes.

SUMMARY

Seven years' study of the effect of increasing potash in the fertilizer for sweetpotatoes was made on Orangeburg sandy loam and Norfolk sandy loam near Florence, S. C.

Fertilizer mixtures all contained 3 percent of nitrogen and 8 percent of phosphoric acid; the potash was varied for the several mixtures from 0 to 15 percent by 3-percent steps. All treatments were at the rate of 500 pounds per acre.

The Porto Rico variety was grown all 7 years and Nancy Hall and Big Stem Jersey the last 4 years. All treatments were replicated four or five times, being distributed systematically within blocks.

The produce of each plot was graded into Jumbo, U. S. No. 1, and U. S. No. 2 grades and weighed at harvest. "Strings" were left in the field. Roots of all grades from the 3–8–3 and 3–8–15 treatments were measured for length and diameter for determining shape index.

Yield and grade data were analyzed by Snedecor's modification of Fisher's method of analysis of variance. Shape indexes were analyzed by determining means and probable errors of various groups or strata of data.

Increasing potash up to 9 (sometimes 12) percent produced small increases in yield of Jumbos, No. 1's, and total yields; fertilizers with 15 percent potash usually produced an insignificant decrease below the yields for 9 or 12 percent. In general, no significant differences in yield were produced between fertilizers with 6 percent of potash and any higher amount.

Increasing potash produced consistent significant increases in percentage of Jumbos, slight but insignificant increases in percentage of No. 1's, and slight and generally insignificant decreases in percentage of No. 2's.

Fertilizers containing 15 versus 3 percent of potash produced roots that were thicker in proportion to length, but the differences were so small as to be of no practical importance, despite statistical significance.

CONCLUSION

These studies on Orangeburg sandy loam and Norfolk sandy loam in the Coastal Plain area of South Carolina show but relatively small increases in yield of sweetpotatoes with increasing amounts of potash in 500-pound per acre applications of mixtures which also contained 3 percent of nitrogen and 8 percent of phosphoric acid. They are markedly at variance with results obtained from fertilizer studies involving potash in New Jersey, Virginia, Maryland, Georgia, and Florida, but agree rather closely with results obtained in coastal parts of North Carolina and in Mississippi and Louisiana.

It seems that recommendations have been based too much on the phenomenal increases from potash on sweetpotatoes in some States, and with too little recognition that those results are not generally applicable. These studies emphasize the need for additional regional and local tests to permit the best possible recommendations being made on a more localized basis. Before recommendations are made for applying potash in excess of 40 to 50 pounds of K_2O per acre (equivalent to 700 to 800 pounds of a mixture containing 6 percent of K_2O) there should be conclusive evidence that larger quantities will be profitable.

There is, of course, good evidence in some of the publications reviewed here that more than 50 pounds is required, but care should be taken that the mistake is not made of trying to apply those findings in places where they do not fit.

From these studies it appears probable that marked effects of potash upon shape of sweetpotatoes will be found only when it is supplied under conditions of relatively serious natural potash deficiency.

Although the three important commercial varieties observed in this work give the same kind of yield response to potash applications, it appears that the Porto Rico may be somewhat more responsive than Nancy Hall or Big Stem Jersey under the conditions of these studies.

The shape of Porto Rico was influenced by potash slightly more than Nancy Hall or Big Stem Jersey, but still to an unimportant degree.

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